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Effect of UV irradiation on CR-39

Antony Joseph and K M Varier
Physics Department, Calicut University, Kerala-673 635, India

Abstract : Dependence of bulk etch rate, track etch rate and track diameter growth rate on u.v. absorption of CR-39 track detector has been studied. Comparison is made on the response of the detector to same total absorbed doses of gamma rays and u.v. rays.

Keywords : Track detectors, CR-39, UV irradiation, bulk and track etch rates, track diameter.

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1. Introduction

Environmental conditions affect the characteristics of latent and etched nuclear tracks in solid state nuclear track detectors. This property could be used as a technique for enhancing the sensitivity of the track detectors. It also enables the track detectors to be used as dosimeters for various monitoring purposes. The role of gamma radiation in this aspect has amply been evidenced in the investigations of Blatchley *et al* (1982), Zamani and Stef (1984), Asfar *et al* (1984) and Syed *et al* (1985). We also had estimated qualitatively and quantitatively the effect of various total doses of gamma rays on the response of one particular batch of CR-39 detectors (Joseph and Varier 1987). High energy electrons and X-rays also have similar effect on track detectors (Tretyakova and Mamonova 1978, Desorbo 1979).

Ultraviolet rays also has its role as an external agency for enhancing the track etch rate and bulk etch rate of track detectors. In view of the varied uses of the polycarbonate detector CR-39, a clear knowledge of its response to uv radiation is very important. The studies on this aspect of CR-39 was initiated by Cartwright *et al* (1978) and continued by Wong and Hobery (1982) and Arif *et al* (1988).

Since we have observed batch by batch variation of various properties of CR-39 sheets obtained from Pershore Mouldings, England, it was thought worthwhile to study the effect of uv irradiation on the batch of detectors being used in our laboratory.

2. Experimental details

CR-39 detector sheet (thickness $\approx 300\mu$) obtained from Pershore Mouldings, England, was cut into small pieces of area 30 mm × 10 mm. These have a maximum

absorption of 87% of incident uv radiation at 227 nm. For our uv irradiation purposes, we used a Philips (Holland) 15 watts ultraviolet lamp 40 cm long. Its emission spectrum shows a maximum around the same region. By making use of the ability of uv radiation to reduce ferric compounds to ferrous, we estimated the amount of uv radiation falling per unit area at a distance of 29 cm from the axis of the lamp. This calibration method is known as Potassium Ferri oxalate actinometry (Jagger 1967). The amount of uv radiation falling per unit area at this distance was found to be 4.696 Joules.

The detector sheets were first irradiated with 5.3 MeV alpha rays from a Po^{210} source obtained from BARC, Bombay. The alpha irradiation set up was the same as that used in one of our earlier studies (Ravindran *et al* 1985). Soon after the alpha irrradiation, the detector sheets were subjected to uv exposure. The exposure of each sheet to uv rays was started at different times in order to complete the exposure of the different sheets simultaneously. The sheets were then etched in 6N NaOH at 70 $\pm$ 1°C. The etching was repeated for different intervals under identical conditions and after each interval the thickness and diameter distributions were determined. For the thickness measurement a Michelson interferometer was used. The track diameter measurement was made using a Carl Zeiss optical microscope of magnification X600 and a filar eye-piece.

3. Results and discussion

The maximum total dose of uv rays to which we exposed the CR-39 detector sheets was 152 Joules, corresponding to an absorbed dose of about 130 Joules. The bulk etch rate V_B was found to increase by about 50% only. The variation with dose could be fitted to a line with the slope 2.9×10^{-3} μm/hr/Joule. In our earlier gamma ray irradiation experiment on CR-39 (Joseph and Varier 1987) 61 Joules of absorbed gamma rays had resulted in a six fold increase in the bulk etch rate. It was observed by Arif *et al* (1986) that a very high absorbed dose of about 8200 Joules of uv rays increases the bulk etch rate of CR-39 by a factor of approximately twenty. Wong and Hobery (1982) observed a three fold increase only in V_B for a total absorbed dose of over 2500 J of uv rays from the sun. So it may therefore be concluded that the chemical response of CR-39 to gamma irradiation is different from that of uv irradiation having the same total dose. Changes produced in the structure become appreciable only at higher doses of uv rays.

On each detector sheet, the alpha particle-track diameters were found to be distributed around a particular mean value and the diameter corresponding to the peak of the distribution was taken as the average track diameter. Table 1 shows the average track diameter for each uv exposure dose at different etching times.

The track diameter growth rate V_D is calculated for each total dose of uv rays. Its variation with uv dose is depicted in Table 2.

Up to the above maximum absorbed dose of 130 J the track diameter growth rate is found to vary as ab^x where $a = 1.238$, $b = 1.007$ and x is the absorbed dose in Joules.

Table 1. Track diameters for various uv exposures.

UV exposure dose (Joules)	Track diameter (μm) after etching for		
	3 hrs.	6 hrs.	7.5 hrs.
0	3.37	7.65	9.69
5	3.77	8.6	10.3
30	4.18	8.47	11.32
101	5.00	13.36	18.05
152	6.22	19.89	27.64

The track etch rate V_T was extracted from the observation on the track diameter and bulk etch rates using the formula prescribed by Somogyi (1973). A three fold increase in V_T was observed when uv dose was varied from zero to maximum.

Table 2. Track diameter growth rate.

UV Dose (Joules)	V_D (μm/hr.)
0	1.23
5	1.32
30	1.44
101	2.10
152	3.00

4. Conclusion

Since V_D and V_T were affected much more than V_B by uv irradiation, the ratio V_T/V_B was enhanced for the batch of CR-39 used in our lab. Therefore, uv irradiation can be used to sensitise the detector sheets. Also, the track detector can be used as a uv dosimeter.

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